Method to control the magnetic alloy-encapsulated carbon-base nanostructures

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Field of the invention

The present invention relates to a method to control the magnetic alloy-encapsulated carbon-base nanostructure. More specifically the invention is related to control the size, shape and the directional growth of magnetic alloy-encapsulated carbon-base nanostructure which manipulates the magnetic anisotropy and coercive force to store the magnetic signals with nano-resolution.

Background of the invention

The application of carbon nanotube technology becomes popular and attractive to overcome the existing bottleneck for high density magnetic data storage. The technology development of present horizontal magnetic recording media reaches a limit, because of the phenomenon of superparamagnetism. As the recording bit size is too small and too close, the magnetic head or the magnetic cell fails to provide data storage due to regional disturbance and ambient temperature effects. To

promote the data storage capacity, various inventions of discontinuously vertical magnetic thin layer technology were developed. The present research for discontinuous magnetic thin layer technology was merely studied academically. Data storage capacity was limited due to the high cost and limited data storage by use of photolithography.

In fact, the magnetic alloy-encapsulated carbon nanotubes fabricated by the electron cyclotron resonance chemical vapor deposition (ECR-CVD) feature has one discontinuous magnetic thin layer. The conventional method of making carbon nanotubes is first to deposit metal catalyst on the substrate by physical vapor deposition (PVD), then pretreat the substrate by hydrogen plasma, and finally apply chemical vapor deposition (CVD). The morphology of carbon nanotubes grown with various deposition conditions and hydrocarbon gas contents is showing in FIG.4. However, the drawback of such methods is not being able to effectively control the size and shape of the nanostructures. The magnetic catalyst on the tip of nanotubes possesses not only a low coercive force but also a little magnetic anisotropy, which limits the possibility for the high density magnetic recording.

Object of this invention

Therefore, the main object of the present invention is to provide an effective way of controlling the size, shape, and directional growth of nanostructure.

Another object of the present invention is to provide an effective way to increase the media recording density of the nanostructures, which exhibits magnetic shielding effect to prevent mutual annoyance with high magnetic anisotropy and coercive force.

Accordingly, the present invention provides a method to control the magnetic

alloy-encapsulated carbon-base nanostructures, which consists of growing the magnetic alloy-encapsulated carbon-base nanostructures and post treatment for improved magnetic anisotropy by microwave plasma electron cyclotron resonance chemical vapor deposition (deposition) at the power between 500W and 5000W and the working pressure less than 5×10^{-3} Torr; the catalyst and additive on surface of substrate using DC bias and heating treatment at temperature between 400°C and 850 °C and then etching the substrate during plasma pretreatment; and the reaction gas with the electron cyclotron resonance microwave plasma deposition so as to form nanostructures.

Summary of the invention

Accordingly, the present invention discloses a method to control the magnetic alloy-encapsulated carbon-base nanostructures, apply an appropriate amount of magnetic field during magnetic alloy-encapsulated nanostructure deposition and post treatment for improved magnetic anisotropy by electron cyclotron resonance chemical vapor deposition of the catalyst and additive on the surface of substrate using DC bias and heating treatment, and then etching the substrate during plasma pretreatment. The present invention provides control of the size, shape and arrangement of the nanostructures, capability to be effectively manipulated by the magnetic anisotropy and coercive force of the encapsulated magnetic nanoparticles, and capability to store the magnetic signals with nano-resolution.

Brief description of the drawings

The present invention will be better understood from the following detailed

description of preferred embodiments of the invention, taken in conjunction with the accompanying drawings, in which

FIG. 1 is a scanning electron microscope (SEM) diagram of nanostructure produced according to the present invention;

FIG. 2-1 is an atomic force microscope (AFM) diagram of nanostructure produced according to the present invention;

FIG. 2-2 is a magnetic force microscope (MFM) diagram of nanostructure produced according to the present invention;

FIG. 3 is a property list which compares conventional and present invention nanotubes; and

FIG. 4 is a scanning electron microscope (SEM) diagram of nanostructure according to the conventional invention.

Description of the preferred embodiments

The following descriptions of the preferred embodiments are provided to understand the features and the structures of the present invention.

Please refer to FIG. 1, FIG. 2-1, FIG. 2-2, FIG. 3 and FIG. 4, the FIG. 1 discloses a scanning electron microscope (SEM) diagram of nanostructure having Fe+Pt catalyst according to the present invention. The FIG. 2-1 and FIG. 2-2 disclose atomic force microscope (AFM) diagram and magnetic force microscope (MFM) diagram of nanostructure according to the present invention. FIG. 3 discloses a property list that compares conventional and present invention nanotubes. From the mentioned above, the present invention is to provide control of the size, shape, directional growth of the nanostructures, and capability to be effectively manipulated by the magnetic anisotropy and coercive force of the

encapsulated magnetic nanoparticles. A significant isolated effect in high density magnetic recording media was stored in the magnetic signal with nano-resolution to avoid disturbance.

A method to control the magnetic alloy-encapsulated carbon-base nanostructures comprises growing the magnetic alloy-encapsulated carbon-base nanostructures using a magnetic field during magnetic alloy-encapsulated nanostructure deposition and post treatment for improved magnetic anisotropy by electron cyclotron resonance microwave plasma deposition (chemical vapor deposition) at the power between 500W and 5000W and the working pressure less than 5×10^{-3} Torr; applying the catalyst and additive on surface of the substrate using DC bias and heating treatment at temperature between 400°C and 850°C and then etching the substrate during plasma pretreatment, and providing the reaction gas with chemical vapor deposition so as to form nanostructures. The catalyst of the surface substrate and the appropriate additive are selected from the group consisting of magnetic metal and alloy thereof. Therefore, the catalyst is selected from the group consisting of carbon-soluble metal such as iron (Fe), cobalt (Co), nickel (Ni), and alloy thereof such as iron- platinum (Fe-Pt) alloy, cobalt-platinum (Co-Pt), and nonmetal such as silicon (Si). Moreover, the catalyst comprises permanent magnetic rare earth element alloy having carbon solubility such as $Nd_2Fe_{14}B$, $Sm(Co,Cu)_5$, and the catalyst includes lanthanides and alloy thereof. The additives change the catalyst activity or control the size, shape, directional growth and magnetic property of the nanostructures, which is selected from the group consisting of copper (Cu), gold (Au), platinum (Pt) and lanthanides such as the platinum (Pt) additive adding in iron- cobalt (Fe-Co) alloy catalyst. Therefore, the additive to change coercive force of the catalyst, single magnetic

domain grain size, and magnetic anisotropy is selected from the group consisting of copper (Cu), gold (Au), nitrogen (N), chromium (Cr), boron (B), titanium (Ti), vanadium (V), zirconium (Zr), yttrium (Y) and lanthanides.

Next, the plasma pretreatment is to change the size, shape and activity of the catalyst, and control the size, shape, and directional growth of the carbon-base nanostructures. The substrate with enduring high- temperature metal or nonmetal is selected from the group consisting of silicon chip, stainless steel and quartz glass. The metal or nonmetal formed on the substrate using the catalyst by being selected from the group consisting of physical vapor deposition, chemical vapor deposition, electrochemistry, coating, and transfer printing. The physical vapor deposition is selected from the group consisting of sputtering and evaporating. The chemical vapor deposition is plasma enhanced chemical vapor deposition or general chemical vapor deposition. The electrochemistry is selected from the group consisting of electroplating and electroless plating. The coating has a metal salt or alloy salt thereof of catalyst, is formed on the substrate by being selected from the group consisting of rotating coating and immersion plating, and then subjecting the metal catalyst or alloy catalyst with heating and reducing with a plasma pretreatment having hydrogen. The transfer printing proceeds with a metal salt or alloy salt thereof of catalyst, is formed on the substrate by rubber elastomer, and then subjecting the metal catalyst or alloy catalyst with heating and reducing with a plasma pretreatment of hydrogen. The surface patterning of the substrate is a catalyst metal thin layer or grain layer by being selected from the group consisting of photo engraving process, electron beam lithography, printing, transfer printing and ion implantation. The catalyst on the substrate surface is a patterned uniform thin layer or grain layer. Another, catalytic substrate surface is a non-uniform thin

layer pattern or grain layer pattern. The reaction gas is selected from the group consisting of carbon-containing gas and nitrogen-containing gas. The carbon-containing gas is selected from the group consisting of methane, ethane, propane, acetylene, benzene and mixture thereof. The nitrogen-containing gas is selected from the group consisting of ammonia, nitrogen and mixed gas of chemical ammonia- base compound mixture of methane, ethane, propane, acetylene, benzene and mixture thereof. Therefore, the above mentioned achieve the method of control of the magnetic alloy- encapsulated carbon- base nanostructures.

The following shows perfect embodiments according to the method of control the magnetic alloy- encapsulated carbon- base nanostructures.

First, the iron (Fe) target having platinum (Pt) additive is deposited as the thin layer of thickness between 5 and 15nm on the silicon wafer by the physical vapor deposition (PVD), and then is annealed at 600 °C for 10 minutes. Another, the specimen having a magnetic alloy (or metal) and additive is put into a chamber of chemical vapor deposition at 875 Gauss magnetic field, and then hydrogen plasma pretreatment is conducted from 0 minute to 20 minutes with DC bias from 80 to 200 volts and heat treatment is conducted at a temperature between 600 °C and 700°C and at the hydrogen flow rate between 5 sccm and 15 sccm. Last, the deposited nanostructure of specimen with a mixture of methane and hydrogen (15:15 sccm/ sccm) under the magnetic field, and then the nanostructure use the magnetic annealing of deposited nanostructure to show SEM diagram in FIG. 1. FIG. 2-1 and FIG. 2-2 are AFM and MFM diagram according to FIG. 1, wherein FIG. 2-1 show the surface image of carbon nanotubes having different brightness present to height such as the bright part to show higher than the dark part, wherein FIG. 2-2 show MFM image of FIG.2-1 having different brightness present to force such as

the bright part to show repulsive force and the dark part to show attractive force. In the illustrated embodiment, it prove to magnetic alloy-encapsulated carbon-base nanostructure using the magnetic direction to present "1" and "0" that store magnetic recording media with magnetic signal distribution of FIG. 2-1 and FIG. 2-2. Please referring to FIG.3 discloses coercive force of iron-platinum (Fe-Pt) alloy catalyst according to present invention which is better than iron (Fe) conventional catalyst such as the coercive force to change from 750 Oe to 802 Oe. To improve magnetic property, it will desirable to add 875-Gauss magnetic field. FIG. 4 is a scanning electron microscope (SEM) diagram of nanostructure according to the conventional invention, and the collimation and magnetic property are inferior to the present invention.

In summation of the foregoing section, the invention herein fully complies will all new patent application requirement and is hereby submitted to the patent bureau for review and granting of the commensurate patent rights.

The present invention may be embodied in other specific forms without departing from the spirit of the essential attributes thereof; therefore, the illustrated embodiment should be considered in all respects as illustrative and not restrictive, reference being made to the appended claims rather than to the foregoing description to indicate the scope of the invention.